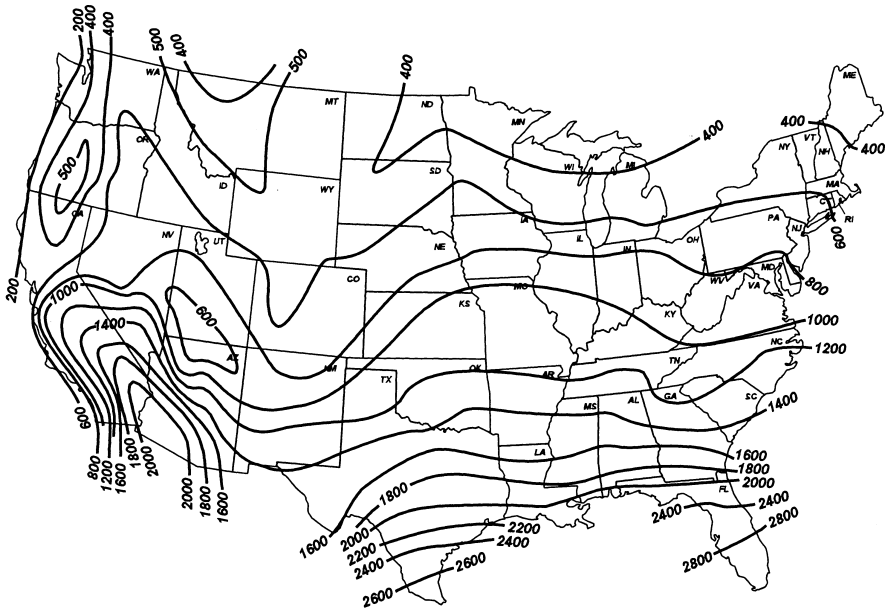

Figure 3 Cooling Load Hours (CLH_A) for the United States

[70 FR 59135, Oct. 11, 2005, as amended at 72 FR 59922, Oct. 22, 2007]

EDITORIAL NOTE: At 72 FR 59922, Oct. 22, 2007, appendix M to subpart B of part 430 was amended; however, portions of the amendment could not be incorporated due to inaccurate amendatory instruction.

APPENDIX N TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF FURNACES AND BOILERS

NOTE: The procedures and calculations that refer to standby mode and off mode energy consumption (*i.e.*, sections 8.6 and 10.9 of this appendix N) need not be performed to determine compliance with energy conservation standards for furnaces and boilers at this time. However, any representation related to standby mode and off mode energy consumption of these products made after April 18, 2011 must be based upon results generated under this test procedure, consistent with the requirements of 42 U.S.C. 6293(c)(2). After July 1, 2010, any adopted energy conservation standard shall address standby mode and off mode energy consumption, and upon the compliance date for such standards, compliance with the applicable provisions of this test procedure will be required.

1.0 Scope. The scope of this appendix is as specified in section 2.0 of ANSI/ASHRAE Standard 103–1993.

2.0 Definitions. Definitions include the definitions specified in section 3 of ANSI/ASHRAE Standard 103–1993 and the following additional and modified definitions:

2.1 *Active mode* means the condition during the heating season in which the furnace or boiler is connected to the power source, and either the burner, electric resistance elements, or any electrical auxiliaries such as blowers or pumps, are activated.

2.2 *ANSI/ASHRAE Standard 103–1993* means the test standard published in 1993 by ASHRAE, approved by the American National Standards Institute (ANSI) on October 4, 1993, and entitled "Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers" (with errata of October 24, 1996).

2.3 *ASHRAE* means the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

2.4 *IEC 62301* means the test standard published by the International Electrotechnical Commission (IEC), titled "Household electrical appliances—Measurement of standby power," Publication 62301 (First Edition 2005–06). (incorporated by reference, *see* § 430.3)

2.5 *Isolated combustion system.* The definition of isolation combustion system in section 3 of ANSI/ASHRAE Standard 103–1993 is

incorporated with the addition of the following: "The unit is installed in an un-conditioned indoor space isolated from the heated space."

2.6 *Off mode* means the condition during the non-heating season in which the furnace or boiler is connected to the power source, and neither the burner, electric resistance elements, nor any electrical auxiliaries such as blowers or pumps, are activated.

2.7 *Seasonal off switch* means the switch on the furnace or boiler that, when activated, results in a measurable change in energy consumption between the standby and off modes.

2.8 *Standby mode* means the condition during the heating season in which the furnace or boiler is connected to the power source, and neither the burner, electric resistance elements, nor any electrical auxiliaries such as blowers or pumps, are activated.

2.9 *Thermal stack damper* means a type of stack damper which is dependent for operation exclusively upon the direct conversion of thermal energy of the stack gases to open the damper.

3.0 Classifications. Classifications are as specified in section 4 of ANSI/ASHRAE Standard 103–1993.

4.0 Requirements. Requirements are as specified in section 5 of ANSI/ASHRAE Standard 103–1993.

5.0 Instruments. Instruments must be as specified in section 6 of ANSI/ASHRAE Standard 103–1993.

6.0 Apparatus. The apparatus used in conjunction with the furnace or boiler during the testing shall be as specified in section 7 of ANSI/ASHRAE Standard 103–1993 except for the second paragraph of section 7.2.2.2 and except for section 7.2.2.5, and as specified in section 6.1 of this appendix.

6.1 *Downflow furnaces.* Install the internal section of vent pipe the same size as the flue collar for connecting the flue collar to the top of the unit, if not supplied by the manufacturer. Do not insulate the internal vent pipe during the jacket loss test (if conducted) described in section 8.6 of ANSI/ASHRAE Standard 103–1993 or the steady-state test described in section 9.1 of ANSI/ASHRAE Standard 103–1993. Do not insulate the internal vent pipe before the cool-down and heat-up tests described in sections 9.5 and 9.6, respectively, of ANSI/ASHRAE Standard 103–1993. If the vent pipe is surrounded by a metal jacket, do not insulate the metal jacket. Install a 5-ft test stack of the same cross sectional area or perimeter as the vent pipe above the top of the furnace. Tape or seal around the junction connecting the vent pipe and the 5-ft test stack. Insulate the 5-ft test stack with insulation having an R-value not less than 7 and an outer layer of aluminum foil. (See Figure 3–E of ANSI/ASHRAE Standard 103–1993.)

7.0 Testing conditions. The testing conditions shall be as specified in section 8 of ANSI/ASHRAE Standard 103–1993 with errata of October 24, 1996, except for section 8.6.1.1; and as specified in section 7.1 of this appendix.

7.1 *Measurement of jacket surface temperature.* The jacket of the furnace or boiler shall be subdivided into 6-inch squares when practical, and otherwise into 36-square-inch regions comprising 4 in. × 9 in. or 3 in. × 12 in. sections, and the surface temperature at the center of each square or section shall be determined with a surface thermocouple. The 36-square-inch areas shall be recorded in groups where the temperature differential of the 36-square-inch area is less than 10 °F for temperature up to 100 °F above room temperature and less than 20 °F for temperature more than 100 °F above room temperature. For forced air central furnaces, the circulating air blower compartment is considered as part of the duct system and no surface temperature measurement of the blower compartment needs to be recorded for the purpose of this test. For downflow furnaces, measure all cabinet surface temperatures of the heat exchanger and combustion section, including the bottom around the outlet duct, and the burner door, using the 36 square-inch thermocouple grid. The cabinet surface temperatures around the blower section do not need to be measured (See figure 3–E of ANSI/ASHRAE Standard 103–1993.)

8.0 Test procedure. Testing and measurements shall be as specified in section 9 of ANSI/ASHRAE Standard 103–1993 except for sections 9.5.1.1, 9.5.1.2.1, 9.5.1.2.2, 9.5.2.1, and section 9.7.1. ; and as specified in sections 8.1, 8.2, 8.3, 8.4, and 8.5, of this appendix.

8.1 *Input to interrupted ignition device.* For burners equipped with an interrupted ignition device, record the nameplate electric power used by the ignition device, PE_{IG}, or use PE_{IG}=0.4 kW if no nameplate power input is provided. Record the nameplate ignition device on-time interval, t_{IG}, or measure the on-time period at the beginning of the test at the time the burner is turned on with a stop watch, if no nameplate value is given. Set t_{IG}=0 and PE_{IG}=0 if the device on-time is less than or equal to 5 seconds after the burner is on.

8.2 *Gas- and oil-fueled gravity and forced air central furnaces without stack dampers cool-down test.* Turn off the main burner after steady-state testing is completed, and measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ANSI/ASHRAE 103–1993 at 1.5 minutes ($T_{F,OFF}(t_3)$) and 9 minutes ($T_{F,OFF}(t_4)$) after the burner shuts off. An integral draft diverter shall remain blocked and insulated, and the stack restriction shall remain in place. On atmospheric systems with an integral draft diverter or draft hood, equipped with either an electromechanical inlet damper or an

electro-mechanical flue damper that closes within 10 seconds after the burner shuts off to restrict the flow through the heat exchanger in the off-cycle, bypass or adjust the control for the electromechanical damper so that the damper remains open during the cool-down test. For furnaces that employ post purge, measure the length of the post-purge period with a stopwatch. The time from burner OFF to combustion blower OFF (electrically de-energized) shall be recorded as t_p. For the case where t_p is intended to be greater than 180 seconds, stop the combustion blower at 180 seconds and use that value for t_p. Measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ANSI/ASHRAE 103–1993 at the end of post-purge period, t_p ($T_{F,OFF}(t_p)$), and at the time (1.5 + t_p) minutes ($T_{F,OFF}(t_3)$) and (9.0 + t_p) minutes ($T_{F,OFF}(t_4)$) after the main burner shuts off. For the case where the measured tp is less than or equal to 30 seconds, it shall be tested as if there is no post purge and t_p shall be set equal to 0.

8.3 *Gas- and oil-fueled gravity and forced air central furnaces without stack dampers with adjustable fan control—cool-down test.* For a furnace with adjustable fan control, this time delay will be 3.0 minutes for non-condensing furnaces or 1.5 minutes for condensing furnaces or until the supply air temperature drops to a value of 40 °F above the inlet air temperature, whichever results in the longest fan on-time. For a furnace without adjustable fan control or with the type of adjustable fan control whose range of adjustment does not allow for the delay time specified above, the control shall be bypassed and the fan manually controlled to give the delay times specified above. For a furnace which employs a single motor to drive the power burner and the indoor air circulating blower, the power burner and indoor air circulating blower shall be stopped together.

8.4 *Gas-and oil-fueled boilers without stack dampers cool-down test.* After steady-state testing has been completed, turn the main burner(s) OFF and measure the flue gas temperature at 3.75 ($T_{F,OFF}(t_3)$) and 22.5 ($T_{F,OFF}(t_4)$) minutes after the burner shut off, using the thermocouple grid described in section 7.6 of ANSI/ASHRAE 103–1993. During this off-period, for units that do not have pump delay after shutoff, no water shall be allowed to circulate through the hot water boilers. For units that have pump delay on shutoff, except those having pump controls sensing water temperature, the pump shall be stopped by the unit control and the time t^+, between burner shutoff and pump shutoff shall be measured within one-second accuracy. For units having pump delay controls that sense water temperature, the pump shall be operated for 15 minutes and t^+ shall be 15 minutes. While the pump is operating, the inlet water temperature and flow rate shall be maintained at the same values as used during the steady-state test as specified in sections 9.1 and 8.4.2.3 of ANSI/ASHRAE 103–1993.

For boilers that employ post purge, measure the length of the post-purge period with a stopwatch. The time from burner OFF to combustion blower OFF (electrically de-energized) shall be recorded as t_P. For the case where t_P is intended to be greater than 180 seconds, stop the combustion blower at 180 seconds and use that value for t_P. Measure the flue gas temperature by means of the thermocouple grid described in section 7.6 of ANSI/ASHRAE 103–1993 at the end of the post purge period t_P($T_{F,OFF}(t_P)$) and at the time (3.75 + t_P) minutes ($T_{F,OFF}(t_3)$) and (22.5 + t_P) minutes ($T_{F,OFF}(t_4)$) after the main burner shuts off. For the case where the measured t_P is less or equal to 30 seconds, it shall be tested as if there is no post purge and t_P shall be set to equal 0.

8.5 *Direct measurement of off-cycle losses testing method.* [Reserved.]

8.6 Measurement of electrical standby and off mode power.

8.6.1 Standby power measurement. With all electrical auxiliaries of the furnace or boiler not activated, measure the standby power (P_{SB}) in accordance with the procedures in IEC 62301 (incorporated by reference, *see* §430.3), except that section 8.5 *Room Ambient Temperature* of ASHRAE 103—1993 (incorporated by reference, *see* §430.3) and the voltage provision of section 8.2.1.4 *Electrical Supply* of ASHRAE 103—1993 shall apply in lieu of the corresponding provisions of IEC 62301 at section 4.2 *Test room* and the voltage specification of section 4.3 *Power supply*. Frequency shall be 60Hz. Clarifying further, IEC 62301 section 4.5 *Power measurement accuracy* and section 5 *Measurements* shall apply in lieu of section 6.10 *Energy Flow Rate* of ASHRAE 103—1993. Measure the wattage so that all possible standby mode wattage for the entire appliance is recorded, not just the standby mode wattage of a single auxiliary.

8.6.2 Off mode power measurement. If the unit is equipped with a seasonal off switch or there is an expected difference between off mode power and standby mode power, measure off mode power (P_{OFF}) in accordance with the standby power procedures in IEC 62301 (incorporated by reference, *see* §430.3), except that section 8.5 *Room Ambient Temperature* of ASHRAE 103—1993 (incorporated by reference, *see* §430.3) and the voltage provision of section 8.2.1.4 *Electrical Supply* of ASHRAE 103—1993 shall apply in lieu of the corresponding provisions of IEC 62301 at section 4.2 *Test room* and the voltage specification of section 4.3 *Power supply*. Frequency shall be 60Hz. Clarifying further, IEC 62301 section 4.5 *Power measurement accuracy* and section 5 *Measurements* shall apply for this measurement in lieu of section 6.10 *Energy Flow Rate* of ASHRAE 103—1993. Measure the wattage so that all possible off mode wattage for the

entire appliance is recorded, not just the off mode wattage of a single auxiliary. If there is no expected difference in off mode power and standby mode power, let $P_{OFF} = P_{SB,}$ in which case no separate measurement of off mode power is necessary.

9.0 Nomenclature. Nomenclature shall include the nomenclature specified in section 10 of ANSI/ASHRAE Standard 103–1993 and the following additional variables:

Eff_{motor}=Efficiency of power burner motor
PE_{IG}=Electrical power to the interrupted ignition device, kW
$R_{T,a}$=$R_{T,F}$ if flue gas is measured
=$R_{T,S}$ if stack gas is measured
$R_{T,F}$=Ratio of combustion air mass flow rate to stoichiometric air mass flow rate
$R_{T,S}$=Ratio of the sum of combustion air and relief air mass flow rate to stoichiometric air mass flow rate
t_{IG}=Electrical interrupted ignition device on-time, min.
$T_{a,SS,X}$=$T_{F,SS,X}$ if flue gas temperature is measured, °F
=$T_{S,SS,X}$ if stack gas temperature is measured, °F
y_{IG}=ratio of electrical interrupted ignition device on-time to average burner on-time
y_P=ratio of power burner combustion blower on-time to average burner on-time
E_{SO} = Average annual electric standby mode and off mode energy consumption, in kilowatt-hours
P_{OFF} = Furnace or boiler off mode power, in watts
P_{SB} = Furnace or boiler standby mode power, in watts

10.0 Calculation of derived results from test measurements. Calculations shall be as specified in section 11 of ANSI/ASHRAE Standard 103–1993 and the October 24, 1996, Errata Sheet for ASHRAE Standard 103–1993, except for appendices B and C; and as specified in sections 10.1 through 10.8 and Figure 1 of this appendix.

10.1 *Annual fuel utilization efficiency.* The annual fuel utilization efficiency (AFUE) is as defined in sections 11.2.12 (non-condensing systems), 11.3.12 (condensing systems), 11.4.12 (non-condensing modulating systems) and 11.5.12 (condensing modulating systems) of ANSI/ASHRAE Standard 103–1993, except for the definition for the term $Effy_{HS}$ in the defining equation for AFUE. $Effy_{HS}$ is defined as:

$Effy_{HS}$=heating seasonal efficiency as defined in sections 11.2.11 (non-condensing systems), 11.3.11 (condensing systems), 11.4.11 (non-condensing modulating systems) and 11.5.11 (condensing modulating systems) of ANSI/ASHRAE Standard 103–1993 and is based on the assumptions that all weatherized warm air furnaces or boilers are located out-of-doors, that warm air furnaces which are not weatherized are installed as isolated combustion systems, and that boilers which are not weatherized are installed indoors.

10.2 *National average burner operating hours, average annual fuel energy consumption and average annual auxiliary electrical energy consumption for gas or oil furnaces and boilers.*

10.2.1 *National average number of burner operating hours.* For furnaces and boilers equipped with single stage controls, the national average number of burner operating hours is defined as:

BOH_{SS}=2,080 (0.77) A DHR–2,080 B

where:

2,080=national average heating load hours
0.77=adjustment factor to adjust the calculated design heating requirement and heating load hours to the actual heating load experienced by the heating system
DHR=typical design heating requirements as listed in Table 8 (in unit of kBtu/h) of ANSI/ASHRAE Standard 103–1993, using the proper value of Q_{OUT} defined in 11.2.8.1 of ANSI/ASHRAE Standard 103–1993
A=100,000 / [341,300(y_PPE+$y_{IG}PE_{IG}$+yBE)+(Q_{IN}–Q_P)$Effy_{HS}$], for forced draft unit, indoors
=100,000 / [341,300(y_PPE Eff_{motor}+$y_{IG}PE_{IG}$+yBE)+(Q_{IN}–Q_P)$Effy_{HS}$], for forced draft unit, ICS,
=100,000 / [341,300(y_PPE(1–Eff_{motor})+$y_{IG}PE_{IG}$+yBE)+(Q_{IN}–Q_P)$Effy_{HS}$], for induced draft unit, indoors, and
=100,000 / [341,300($y_{IG}PE_{IG}$+yBE)+(Q_{IN}–Q_P)$Effy_{HS}$], for induced draft unit, ICS
B=2 Q_P($Effy_{HS}$)(A) / 100,000

where:

Eff_{motor}=Power burner motor efficiency provided by manufacturer,
=0.50, an assumed default power burner efficiency if not provided by manufacturer.
100,000=factor that accounts for percent and kBtu
PE=burner electrical power input at full-load steady-state operation, including electrical ignition device if energized, as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103–1993
y_P=ratio of induced or forced draft blower on-time to average burner on-time, as follows:
1 for units without post purge;
1+(t_P/3.87) for single stage furnaces with post purge;
1+(t_P/10) for two-stage and step modulating furnaces with post purge;
1+(t_P/9.68) for single stage boilers with post purge; or
1+(t_P/15) for two stage and step modulating boilers with post purge.
PE_{IG}=electrical input rate to the interrupted ignition device on burner (if employed), as defined in 8.1 of this appendix
y_{IG}=ratio of burner interrupted ignition device on-time to average burner on-time, as follows:
0 for burners not equipped with interrupted ignition device;

(t_{IG}/3.87) for single stage furnaces;
(t_{IG}/10) for two-stage and step modulating furnaces;
(t_{IG}/9.68) for single stage boilers; or
(t_{IG}/15) for two stage and step modulating boilers.

t_{IG}=on-time of the burner interrupted ignition device, as defined in 8.1 of this appendix

t_P=post purge time as defined in 8.2 (furnace) or 8.4 (boiler) of this appendix
=0 if t_P is equal to or less than 30 second.

y=ratio of blower or pump on-time to average burner on-time, as follows:
1 for furnaces without fan delay;
1 for boilers without a pump delay;
$1+(t^+—t^-)/3.87$ for single stage furnaces with fan delay;
$1+(t^+—t^-)/10$ for two-stage and step modulating furnaces with fan delay;
$1+(t^+/9.68)$ for single stage boilers with pump delay; or
$1+(t^+/15)$ for two stage and step modulating boilers with pump delay.

BE=circulating air fan or water pump electrical energy input rate at full load steady-state operation, as defined in ANSI/ASHRAE Standard 103–1993

Q_{IN}=as defined in 11.2.8.1 of ANSI/ASHRAE Standard 103–1993

Q_P=as defined in 11.2.11 of ANSI/ASHRAE Standard 103–1993

$Effy_{HS}$=as defined in 11.2.11 (non-condensing systems) or 11.3.11.3 (condensing systems) of ANSI/ASHRAE Standard 103–1993, percent, and calculated on the basis of:
ICS installation, for non-weatherized warm air furnaces;
indoor installation, for non-weatherized boilers; or
outdoor installation, for furnaces and boilers that are weatherized.

2=ratio of the average length of the heating season in hours to the average heating load hours

t^+=as defined in 9.5.1.2 of ANSI/ASHRAE Standard 103–1993 or 8.4 of this appendix

t^-=as defined in 9.6.1 of ANSI/ASHRAE Standard 103–1993

10.2.1.1 For furnaces and boilers equipped with two stage or step modulating controls the average annual energy used during the heating season, E_M, is defined as:

$$E_M=(Q_{IN}-Q_P)\ BOH_{SS}+(8{,}760-4{,}600)Q_P$$

where:

Q_{IN}=as defined in 11.4.8.1.1 of ANSI/ASHRAE Standard 103–1993

Q_P=as defined in 11.4.12 of ANSI/ASHRAE Standard 103–1993

BOH_{SS}=as defined in section 10.2.1 of this appendix, in which the weighted $Effy_{HS}$ as defined in 11.4.11.3 or 11.5.11.3 of ANSI/ASHRAE Standard 103–1993 is used for calculating the values of A and B, the term DHR is based on the value of Q_{OUT} defined in 11.4.8.1.1 or 11.5.8.1.1 of ANSI/ASHRAE Standard 103–1993, and the term ($y_PPE+y_{IG}PE_{IG}+yBE$) in the factor A is increased by the factor R, which is defined as:

R=2.3 for two stage controls
=2.3 for step modulating controls when the ratio of minimum-to-maximum output is greater than or equal to 0.5
=3.0 for step modulating controls when the ratio of minimum-to-maximum output is less than 0.5

A=$100{,}000/[341{,}300(y_PPE+y_{IG}PE_{IG}+y\ BE)\ R+(Q_{IN}-Q_P)\ Effy_{HS}]$, for forced draft unit, indoors
=$100{,}000/[341{,}300(y_PPE\ Eff_{motor}+y_{IG}PE_{IG}+y\ BE)\ R+(Q_{IN}-Q_P)Effy_{HS}]$, for forced draft unit, ICS,
=$100{,}000/[341{,}300(y_PPE(1–Eff_{motor})+y_{IG}PE_{IG}+y\ BE)\ R+(Q_{IN}-Q_P)\ Effy_{HS}]$, for induced draft unit, indoors, and
=$100{,}000/[341{,}300(y_{IG}PE_{IG}+y\ BE)\ R+(Q_{IN}-Q_P)\ Effy_{HS}]$, for induced draft unit, ICS

where:

Eff_{motor}=Power burner motor efficiency provided by manufacturer,
=0.50, an assumed default power burner efficiency if none provided by manufacturer.

$Effy_{HS}$=as defined in 11.4.11.3 or 11.5.11.3 of ANSI/ASHRAE Standard 103–1993, and calculated on the basis of:
—ICS installation, for non-weatherized warm air furnaces
—indoor installation, for non-weatherized boilers
—outdoor installation, for furnaces and boilers that are weatherized

8,760=total number of hours per year

4,600=as specified in 11.4.12 of ANSI/ASHRAE Standard 103–1993

10.2.1.2 For furnaces and boilers equipped with two stage or step modulating controls the national average number of burner operating hours at the reduced operating mode is defined as:

$$BOH_R=X_RE_M/Q_{IN,R}$$

where:

X_R=as defined in 11.4.8.7 of ANSI/ASHRAE Standard 103–1993

E_M=as defined in section 10.2.1.1 of this appendix

$Q_{IN,R}$=as defined in 11.4.8.1.2 of ANSI/ASHRAE Standard 103–1993

10.2.1.3 For furnaces and boilers equipped with two stage controls the national average number of burner operating hours at the maximum operating mode (BOH_H) is defined as:

$$BOH_H=X_HE_M/Q_{IN}$$

where:

X_H=as defined in 11.4.8.6 of ANSI/ASHRAE Standard 103–1993

E_M=as defined in section 10.2.1.1 of this appendix
Q_{IN}=as defined in 11.4.8.1.1 of ANSI/ASHRAE Standard 103–1993

10.2.1.4 For furnaces and boilers equipped with step modulating controls the national average number of burner operating hours at the modulating operating mode (BOH_M) is defined as:

$BOH_M=X_H E_M/Q_{IN,M}$

where:

X_H=as defined in 11.4.8.6 of ANSI/ASHRAE Standard 103–1993
E_M=as defined in section 10.2.1.1 of this appendix
$Q_{IN,M}=Q_{OUT,M}/(Effy_{SS,M}/100)$
$Q_{OUT,M}$=as defined in 11.4.8.10 or 11.5.8.10 of ANSI/ASHRAE Standard 103–1993, as appropriate
$Effy_{SS,M}$=as defined in 11.4.8.8 or 11.5.8.8 of ANSI/ASHRAE Standard 103–1993, as appropriate, in percent
100=factor that accounts for percent

10.2.2 *Average annual fuel energy consumption for gas or oil fueled furnaces or boilers.* For furnaces or boilers equipped with single stage controls the average annual fuel energy consumption (E_F) is expressed in Btu per year and defined as:

$E_F=BOH_{SS}(Q_{IN}-Q_P)+8{,}760\ Q_P$

where:

BOH_{SS}=as defined in 10.2.1 of this appendix
Q_{IN}=as defined in 11.2.8.1 of ANSI/ASHRAE Standard 103–1993
Q_P=as defined in 11.2.11 of ANSI/ASHRAE Standard 103–1993
8,760=as specified in 10.2.1 of this appendix

10.2.2.1 For furnaces or boilers equipped with either two stage or step modulating controls E_F is defined as:

$E_F=E_M + 4{,}600Q_P$

where:

E_M=as defined in 10.2.1.1 of this appendix
4,600=as specified in 11.4.12 of ANSI/ASHRAE Standard 103–1993
Q_P=as defined in 11.2.11 of ANSI/ASHRAE Standard 103–1993

10.2.3 Average annual auxiliary electrical energy consumption for gas or oil-fueled furnaces or boilers. For furnaces and boilers equipped with single-stage controls, the average annual auxiliary electrical consumption (E_{AE}) is expressed in kilowatt-hours and defined as:

$E_{AE} = BOH_{SS}(y_P PE + y_{IG}PE_{IG} + yBE)+ E_{SO}$

Where:

BOH_{SS} = as defined in 10.2.1 of this appendix
PE = as defined in 10.2.1 of this appendix
y_P = as defined in 10.2.1 of this appendix
y_{IG} = as defined in 10.2.1 of this appendix
PE_{IG} = as defined in 10.2.1 of this appendix
y = as defined in 10.2.1 of this appendix
BE = as defined in 10.2.1 of this appendix
E_{SO} = as defined in 10.9 of this appendix.

10.2.3.1 For furnaces or boilers equipped with two-stage controls, E_{AE} is defined as:

$E_{AE} = BOH_R (y_P PE_R + y_{IG}PE_{IG} + yBE_R) + BOH_H (y_P PE_H + y_{IG}PE_{IG} + y\ BE_H) + E_{SO}$

Where:

BOH_R = as defined in 10.2.1.2 of this appendix
y_P = as defined in 10.2.1 of this appendix
PE_R = as defined in 9.1.2.2 and measured at the reduced fuel input rate of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* §430.3)
y_{IG} = as defined in 10.2.1 of this appendix
PE_{IG} = as defined in 10.2.1 of this appendix
y = as defined in 10.2.1 of this appendix
BE_R = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* §430.3) measured at the reduced fuel input rate
BOH_H = as defined in 10.2.1.3 of this appendix
PE_H = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* §430.3) measured at the maximum fuel input rate
BE_H = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* §430.3) measured at the maximum fuel input rate
E_{SO} = as defined in 10.9 of this appendix.

10.2.3.2 For furnaces or boilers equipped with step-modulating controls, E_{AE} is defined as:

$E_{AE} = BOH_R (y_P\ PE_R + y_{IG}PE_{IG} + yBE_R) + BOH_M (y_P PE_H + y_{IG}PE_{IG} + y\ BE_H) + E_{SO}$

Where:

BOH_R = as defined in 10.2.1.2 of this appendix
y_P = as defined in 10.2.1 of this appendix
PE_R = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* §430.3), measured at the reduced fuel input rate
y_{IG} = as defined in 10.2.1 of this appendix
PE_{IG} = as defined in 10.2.1 of this appendix
y = as defined in 10.2.1. of this appendix
BE_R = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* §430.3) measured at the reduced fuel input rate
BOH_M = as defined in 10.2.1.4 of this appendix
PE_H = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* §430.3) measured at the maximum fuel input rate
BE_H = as defined in 9.1.2.2 of ANSI/ASHRAE Standard 103—1993, (incorporated by reference, *see* §430.3) measured at the maximum fuel input rate
E_{SO} = as defined in 10.9 of this appendix.

10.3 Average annual electric energy consumption for electric furnaces or boilers.

$E_E = 100(2{,}080)(0.77)DHR/(3.412\ AFUE) + E_{SO}$

Where:

100 = to express a percent as a decimal
2,080 = as specified in 10.2.1 of this appendix
0.77 = as specified in 10.2.1 of this appendix
DHR = as defined in 10.2.1 of this appendix
3.412 = conversion to express energy in terms of watt-hours instead of Btu
AFUE = as defined in 11.1 of ANSI/ASHRAE Standard 103—1993 (incorporated by reference, *see* §430.3), in percent, and calculated on the basis of: ICS installation, for non-weatherized warm air furnaces; indoor installation, for non-weatherized boilers; or outdoor installation, for furnaces and boilers that are weatherized.
E_{SO} = as defined in 10.9 of this appendix.

10.4 *Energy factor.*

10.4.1 *Energy factor for gas or oil furnaces and boilers.* Calculate the energy factor, EF, for gas or oil furnaces and boilers defined as, in percent:

$$EF = \frac{\left(E_F - 4{,}600\ Q_P\right) Effy_{HS}}{E_F + 3{,}412\ E_{AE}}$$

where:

E_F=average annual fuel consumption as defined in 10.2.2 of this appendix.
E_{AE}=as defined in 10.2.3 of this appendix.
$Effy_{HS}$=Annual Fuel Utilization Efficiency as defined in 11.2.11, 11.3.11, 11.4.11 or 11.5.11 of ANSI/ASHRAE Standard 103–1993, in percent, and calculated on the basis of:
ICS installation, for non-weatherized warm air furnaces;
indoor installation, for non-weatherized boilers; or
outdoor installation, for furnaces and boilers that are weatherized.
3,412=conversion factor from kilowatt to Btu/h

10.4.2 *Energy factor for electric furnaces and boilers.* The energy factor, EF, for electric furnaces and boilers is defined as:

EF=AFUE

where:

AFUE=Annual Fuel Utilization Efficiency as defined in section 10.3 of this appendix, in percent

10.5 *Average annual energy consumption for furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.*

10.5.1 *Average annual fuel energy consumption for gas or oil-fueled furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements.* For gas or oil-fueled furnaces and boilers the average annual fuel energy consumption for a specific geographic region and a specific typical design heating requirement (E_{FR}) is expressed in Btu per year and defined as:

$E_{FR}=(E_F-8{,}760\ Q_P)(HLH/2{,}080)+8{,}760\ Q_P$

where:

E_F=as defined in 10.2.2 of this appendix
8,760=as specified in 10.2.1 of this appendix
Q_P=as defined in 11.2.11 of ANSI/ASHRAE Standard 103–1993
HLH=heating load hours for a specific geographic region determined from the heating load hour map in Figure 1 of this appendix
2,080=as defined in 10.2.1 of this appendix

10.5.2 Average annual auxiliary electrical energy consumption for gas or oil-fueled furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements. For gas or oil-fueled furnaces and boilers, the average annual auxiliary electrical energy consumption for a specific geographic region and a specific typical design heating requirement (E_{AER}) is expressed in kilowatt-hours and defined as:

$E_{AER} = (E_{AE} - E_{SO})\ (HLH/2080) + E_{SOR}$

Where:

E_{AE} = as defined in 10.2.3 of this appendix
E_{SO} = as defined in 10.9 of this appendix
HLH = as defined in 10.5.1 of this appendix
2,080 = as specified in 10.2.1 of this appendix
E_{SOR} = as specified in 10.5.3 of this appendix.

10.5.3 Average annual electric energy consumption for electric furnaces and boilers located in a different geographic region of the United States and in buildings with different design heating requirements. For electric furnaces and boilers, the average annual electric energy consumption for a specific geographic region and a specific typical design heating requirement (E_{ER}) is expressed in kilowatt-hours and defined as:

$E_{ER} = 100(0.77)\ DHR\ HLH/(3.412\ AFUE) + E_{SOR}$

Where:

100 = as specified in 10.3 of this appendix
0.77 = as specified in 10.2.1 of this appendix
DHR = as defined in 10.2.1 of this appendix
HLH = as defined in 10.5.1 of this appendix
3.412 = as specified in 10.3 of this appendix
AFUE = as defined in 10.3 of this appendix
E_{SOR} = E_{SO} as defined in 10.9 of this appendix, except that in the equation for E_{SO}, the term BOH is multiplied by the expression (HLH/2080) to get the appropriate regional accounting of standby mode and off mode loss.

10.6 *Annual energy consumption for mobile home furnaces*

10.6.1 *National average number of burner operating hours for mobile home furnaces (BOH_{SS}).* BOH_{SS} is the same as in 10.2.1 of this appendix, except that the value of $Effy_{HS}$ in the calculation of the burner operating

hours, BOH_{SS}, is calculated on the basis of a direct vent unit with system number 9 or 10.

10.6.2 *Average annual fuel energy for mobile home furnaces (E_F).* E_F is same as in 10.2.2 of this appendix except that the burner operating hours, BOH_{SS}, is calculated as specified in 10.6.1 of this appendix.

10.6.3 *Average annual auxiliary electrical energy consumption for mobile home furnaces (E_{AE}).* E_{AE} is the same as in 10.2.3 of this appendix, except that the burner operating hours, BOH_{SS}, is calculated as specified in 10.6.1 of this appendix.

10.7 *Calculation of sales weighted average annual energy consumption for mobile home furnaces.* In order to reflect the distribution of mobile homes to geographical regions with average HLH_{MHF} value different from 2,080, adjust the annual fossil fuel and auxiliary electrical energy consumption values for mobile home furnaces using the following adjustment calculations.

10.7.1 For mobile home furnaces the sales weighted average annual fossil fuel energy consumption is expressed in Btu per year and defined as:

$$E_{F,MHF}=(E_F-8{,}760\ Q_P)HLH_{MHF}/2{,}080+8{,}760\ Q_P$$

where:

E_F=as defined in 10.6.2 of this appendix
8,760=as specified in 10.2.1 of this appendix
Q_P=as defined in 11.2.11 of ANSI/ASHRAE Standard 103–1993
HLH_{MHF}=1880, sales weighted average heating load hours for mobile home furnaces
2,080=as specified in 10.2.1 of this appendix

10.7.2 For mobile home furnaces the sales weighted average annual auxiliary electrical energy consumption is expressed in kilowatt-hours and defined as:

$$E_{AE,MHF}=E_{AE}HLH_{MHF}/2{,}080$$

where:

E_{AE}=as defined in 10.6.3 of this appendix
HLH_{MHF}=as defined in 10.7.1 of this appendix
2,080=as specified in 10.2.1 of this appendix

10.8 *Direct determination of off-cycle losses for furnaces and boilers equipped with thermal stack dampers.* [Reserved.]

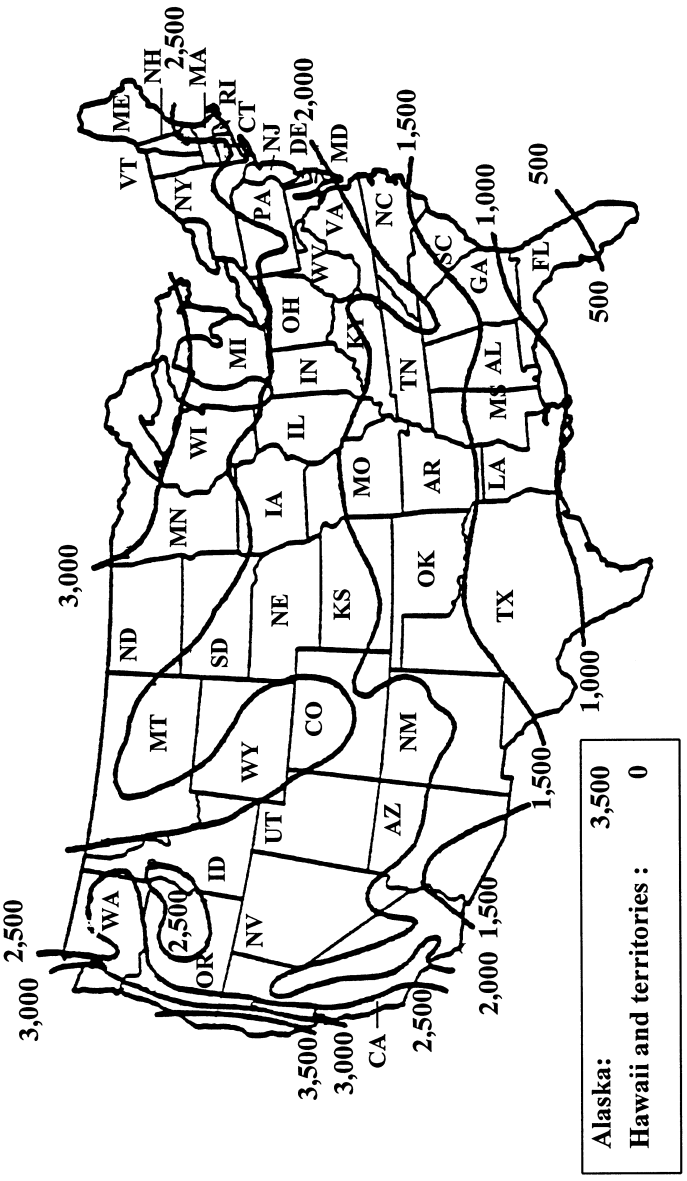

FIGURE 1- HEATING LOAD HOURS (HLH) FOR THE UNITED STATES

10.9 Average annual electrical standby mode and off mode energy consumption. Calculate the annual electrical standby mode and off mode energy consumption (E_{SO}) in kilowatt-hours, defined as:

$E_{SO} = ((P_{SB} * (4160 - BOH)) + (P_{OFF} * 4600)) * K$

Where:

P_{SB} = furnace or boiler standby mode power, in watts, as measured in Section 8.6

4,160 = average heating season hours per year

P_{OFF} = furnace or boiler off mode power, in watts, as measured in Section 8.6

4,600 = average non-heating season hours per year

K = 0.001 kWh/Wh, conversion factor for watt-hours to kilowatt-hours

BOH = total burner operating hours as calculated in section 10.2 for gas or oil-fueled furnaces or boilers. Where for gas or oil-fueled furnaces and boilers equipped with single-stage controls, BOH = BOH_{SS}; for gas or oil-fueled furnaces and boilers equipped with two-stage controls, BOH = (BOH_R + BOH_H); and for gas or oil-fueled furnaces and boilers equipped with step-modulating controls, BOH = (BOH_R + BOH_M). For electric furnaces and boilers, BOH = 100(2080)(0.77)DHR/(E_{in} 3.412)(AFUE))

Where:

100 = to express a percent as a decimal

2,080 = as specified in 10.2.1 of this appendix

0.77 = as specified in 10.2.1 of this appendix

DHR = as defined in 10.2.1 of this appendix

3.412 = conversion to express energy in terms of KBtu instead of kilowatt-hours

AFUE = as defined in 11.1 of ANSI/ASHRAE Standard 103—1993 (incorporated by reference, *see* §430.3) in percent

E_{in} = Steady-state electric rated power, in kilowatts, from section 9.3 of ANSI/ASHRAE Standard 103—1993 (incorporated by reference, *see* §430.3).

[62 FR 26157, May 12, 1997, as amended at 62 FR 53510, Oct. 14, 1997; 75 FR 64631, Oct. 20, 2010]

APPENDIX O TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF VENTED HOME HEATING EQUIPMENT

1.0 Definitions

1.1 "Air shutter" means an adjustable device for varying the size of the primary air inlet(s) to the combustion chamber power burner.

1.2 "Air tube" means a tube which carries combustion air from the burner fan to the burner nozzle for combustion.

1.3 "Barometic draft regulator or barometric damper" means a mechanical device designed to maintain a constant draft in a vented heater.

1.4 "Draft hood" means an external device which performs the same function as an integral draft diverter, as defined in section 1.17 of this appendix.

1.5 "Electro-mechanical stack damper" means a type of stack damper which is operated by electrical and/or mechanical means.

1.6 "Excess air" means air which passes through the combustion chamber and the vented heater flues in excess of that which is theoretically required for complete combustion.

1.7 "Flue" means a conduit between the flue outlet of a vented heater and the integral draft diverter, draft hood, barometric damper or vent terminal through which the flue gases pass prior to the point of draft relief.

1.8 "Flue damper" means a device installed between the furnace and the integral draft diverter, draft hood, barometric draft regulator, or vent terminal which is not equipped with a draft control device, designed to open the venting system when the appliance is in operation and to close the venting system when the appliance is in a standby condition.

1.9 "Flue gases" means reaction products resulting from the combustion of a fuel with the oxygen of the air, including the inerts and any excess air.

1.10 "Flue losses" means the sum of sensible and latent heat losses above room temperature of the flue gases leaving a vented heater.

1.11 "Flue outlet" means the opening provided in a vented heater for the exhaust of the flue gases from the combustion chamber.

1.12 "Heat input" (Q_{in}) means the rate of energy supplied in a fuel to a vented heater operating under steady-state conditions, expressed in Btu's per hour. It includes any input energy to the pilot light and is obtained by multiplying the measured rate of fuel consumption by the measured higher heating value of the fuel.

1.13 "Heating capacity" (Q_{out}) means the rate of useful heat output from a vented heater, operating under steady-state conditions, expressed in Btu's per hour. For room and wall heaters, it is obtained by multiplying the "heat input" (Q_{in}) by the steady-state efficency (η_{ss}) divided by 100. For floor furnaces, it is obtained by multiplying (A) the "heat input" (Q_{in}) by (B) the steady-state efficiency divided by 100, minus the quantity (2.8) (L_j) divided by 100, where L_j is the jacket loss as determined in section 3.2 of this appendix.

1.14 "Higher heating value" (HHV) means the heat produced per unit of fuel when complete combustion takes place at constant pressure and the products of combustion are cooled to the initial temperature of the fuel and air and when the water vapor formed during combustion is condensed. The higher heating value is usually expressed in Btu's per pound, Btu's per cubic foot for gaseous fuel, or Btu's per gallon for liquid fuel.

1.15 "Induced draft" means a method of drawing air into the combustion chamber by mechanical means.

1.16 "Infiltration parameter" means that portion of unconditioned outside air drawn into the heated space as a consequence of loss of conditioned air through the exhaust system of a vented heater.

1.17 "Integral draft diverter" means a device which is an integral part of a vented heater, designed to: (1) Provide for the exhaust of the products of combustion in the